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(54) Abstract Title

Adaptive OFDM receiver where sets of sub-carriers which are coherent are grouped into sub-bands and a single weight is calculated for each sub-band

(57) The present invention relates to an improved adaptive weighting system particular for use with broadband multicarrier systems. Prior art systems determine a series of weights to be applied to each sub-channel of a frequency domain received signal. These weights are then applied to each of the channels according to their coherency. The present invention provides a reduction in the complexity of determining the weights by grouping the sub-channels into groups/sub-bands which are sufficiently coherent to allow narrowband processing and for a single set of weights to be applied to all sub-channels in the sub-band. Thereby reducing the processing required.

The system may use multiple antennas.

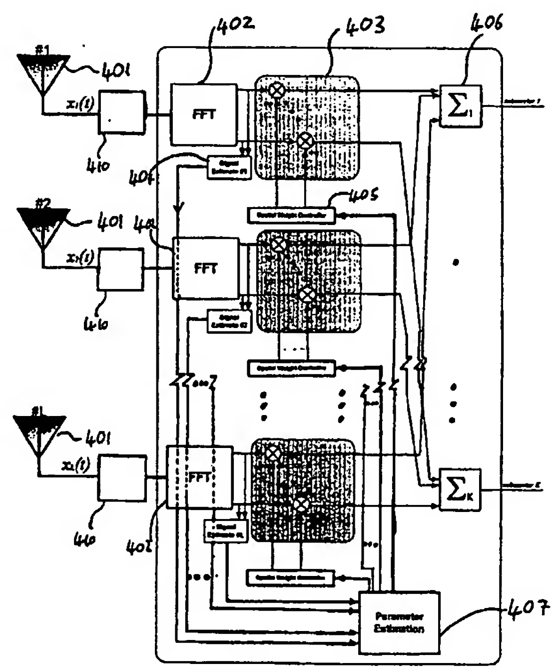

Fig. 4

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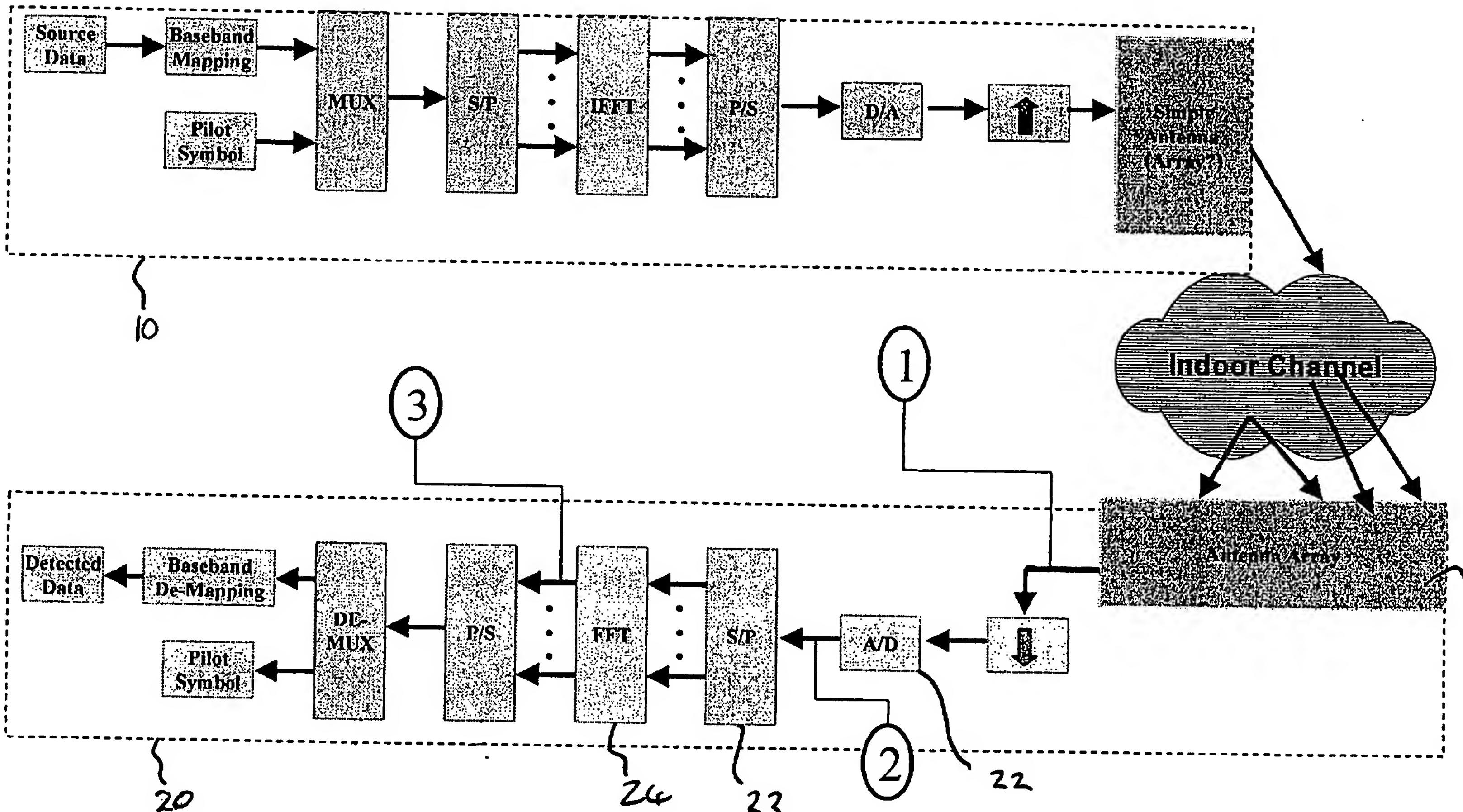

Source Data
Baseband Mapping
Pilot Symbol
MUX
S/P
IFFT
P/S
D/A
Simple Antenna (Array?)
10
Indoor Channel
1
3
Antenna Array
21
A/D
22
2
S/P
23
FFT
24
P/S
DE-MUX
Baseband De-Mapping
Pilot Symbol
Detected Data
20

Fig. 1

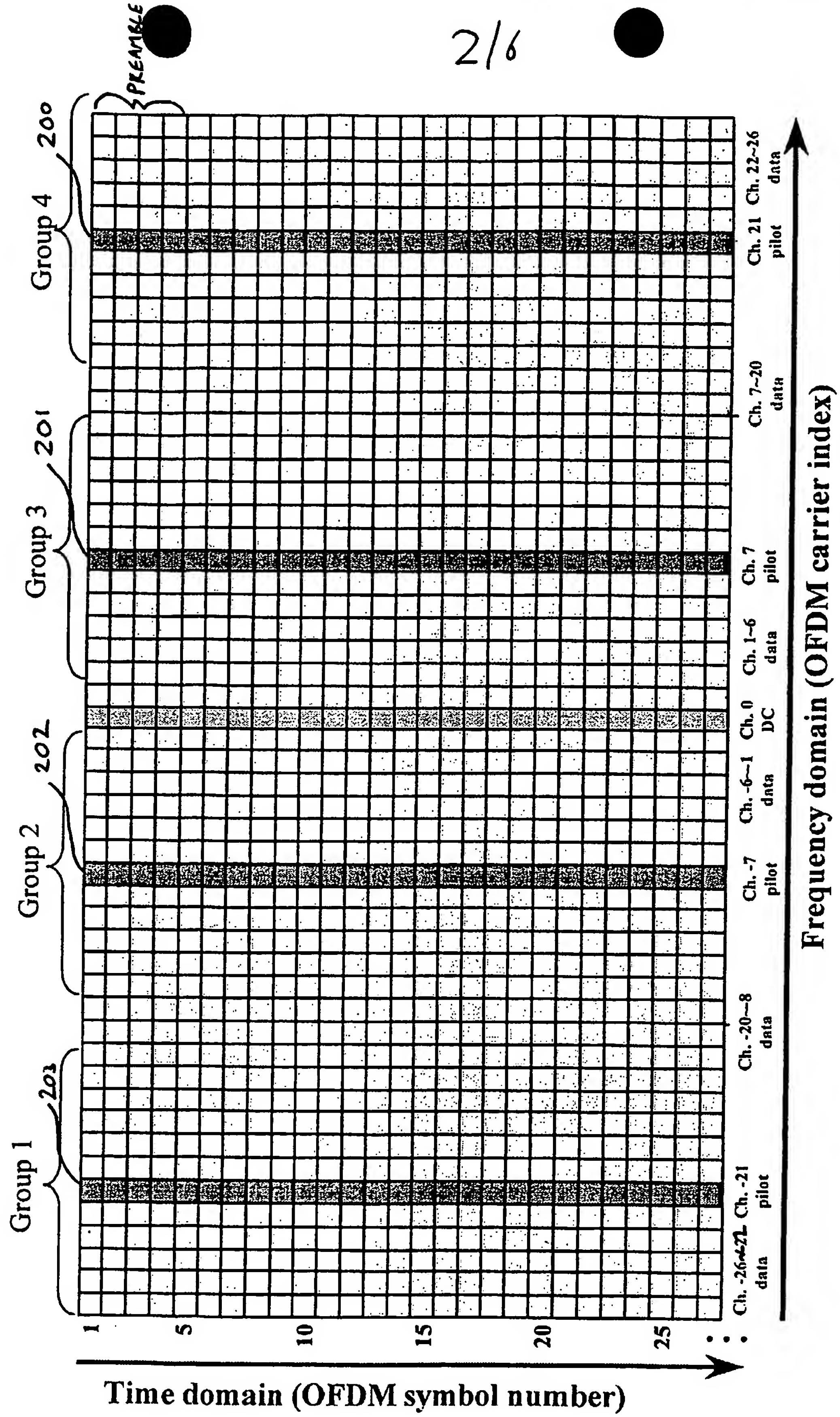
PREAMBLE
200
201
202
203
Group 1
Group 2
Group 3
Group 4
Ch. -26~-22 data
Ch. -21 pilot
Ch. -20~-8 data
Ch. -7 pilot
Ch. -6~-1 data
Ch. 0 DC
Ch. 1~6 data
Ch. 7 pilot
Ch. 7~20 data
Ch. 21 pilot
Ch. 22~26 data
Frequency domain (OFDM carrier index)
1
5
10
15
20
25
Time domain (OFDM symbol number)

Fig. 2

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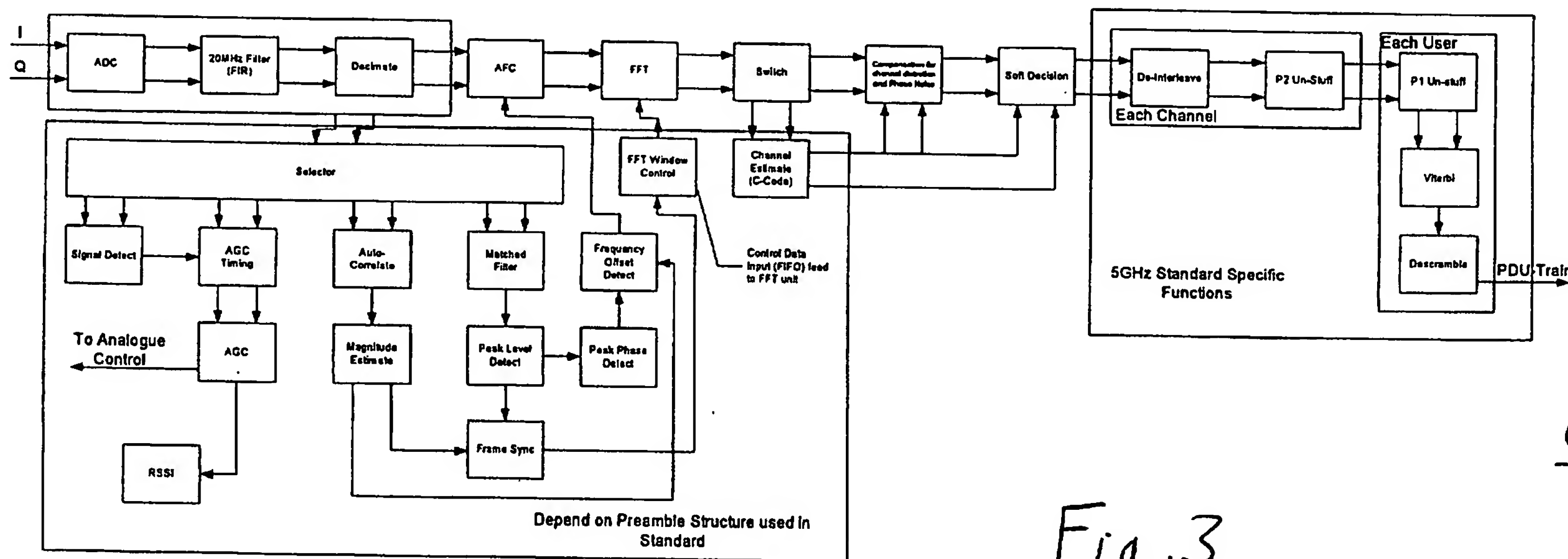

Fig. 3

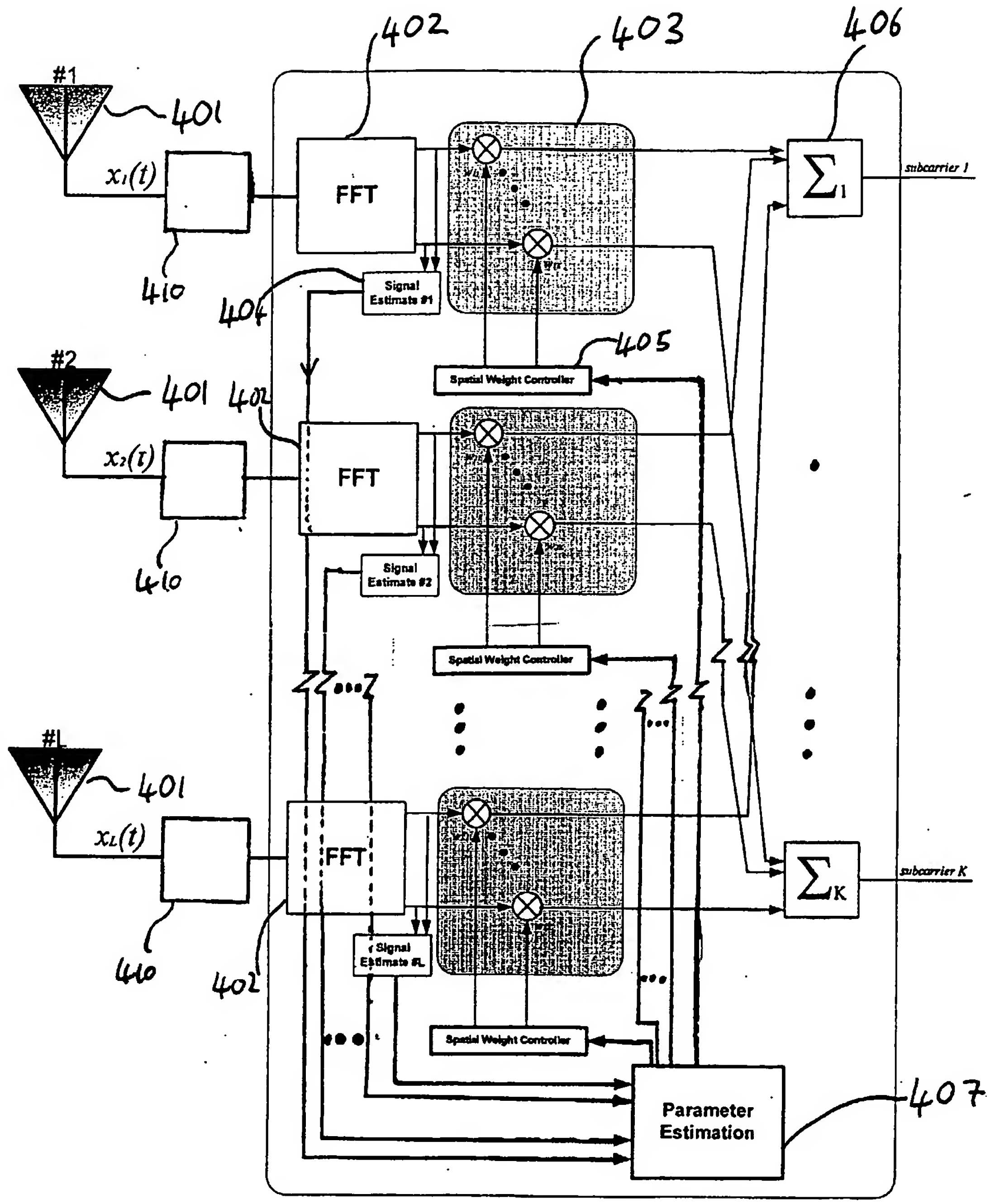
402
403
406
#1
401
$x_1(t)$
FFT
Σ_1
subcarrier 1
410
404
Signal Estimate #1
405
Spatial Weight Controller
#2
401
402
$x_2(t)$
FFT
410
Signal Estimate #2
Spatial Weight Controller
#L
401
$x_L(t)$
FFT
Σ_K
subcarrier K
410
402
Signal Estimate #L
Spatial Weight Controller
Parameter Estimation
407

Fig. 4

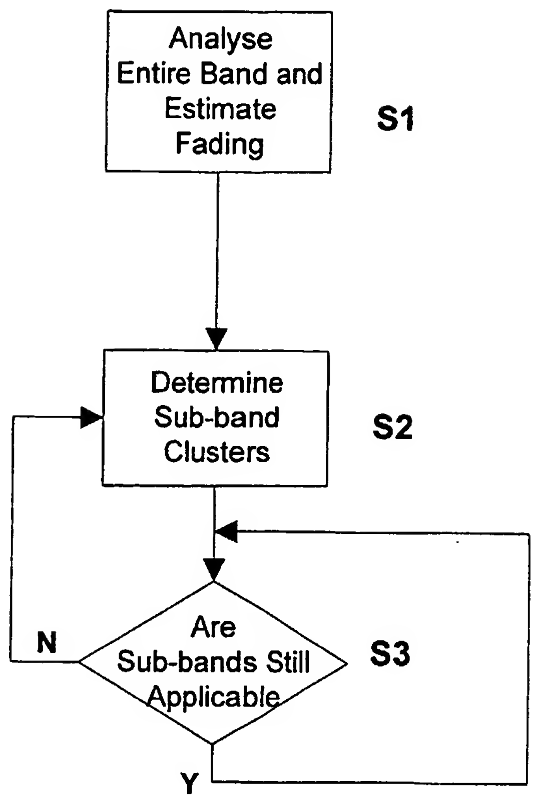
Analyse Entire Band and Estimate Fading
S1
Determine Sub-band Clusters
S2
Are Sub-bands Still Applicable
S3
N
Y

Fig. 5

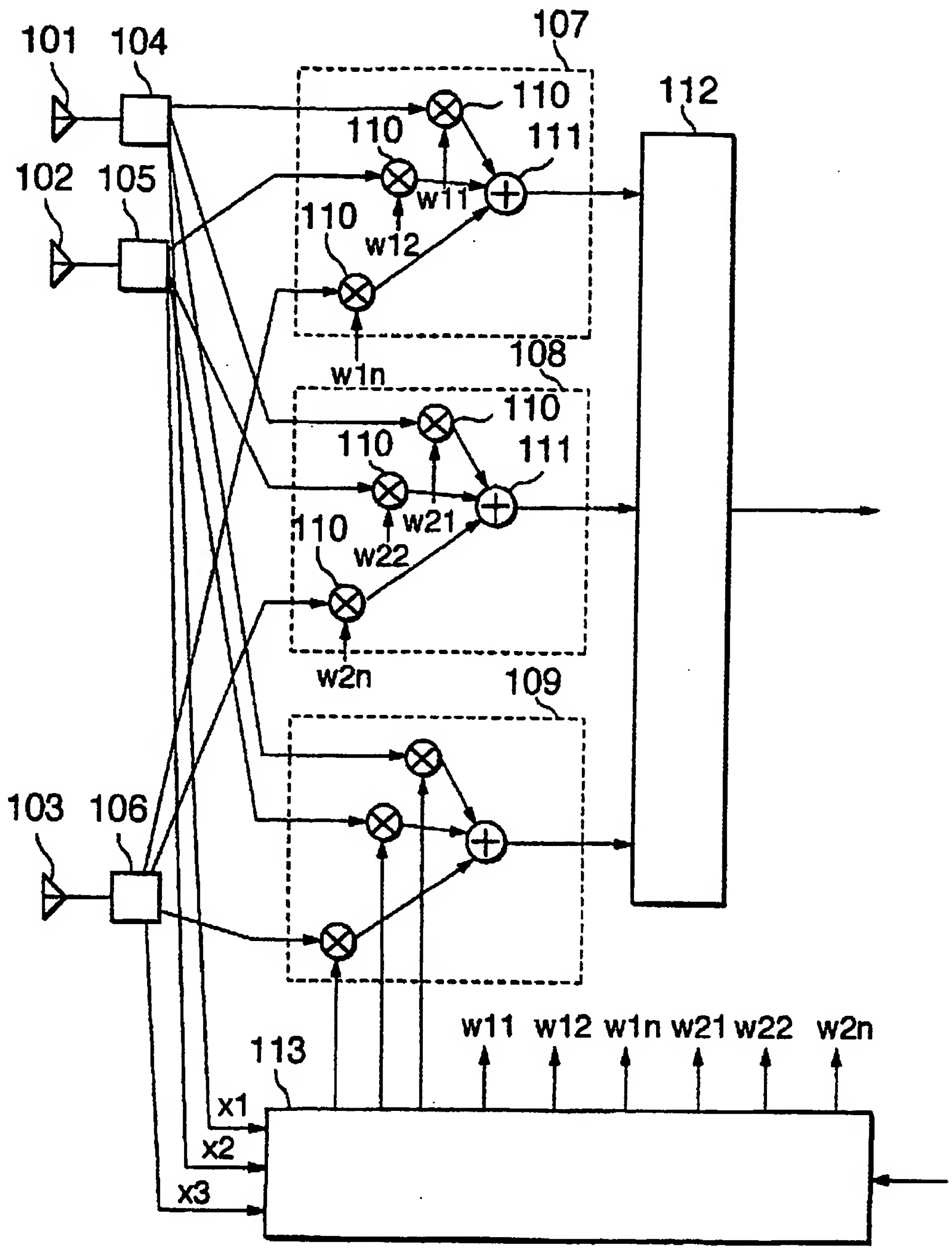
101
104
107
110
111
112
102
105
w11
w12
w1n
108
w21
w22
w2n
109
103
106
113
x1
x2
x3
w11 w12 w1n w21 w22 w2n

Fig. 6

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ADAPTIVE ANTENNA

The present invention relates to a multi-carrier or Orthogonal Frequency Division Multiplexing (OFDM) system employing multiple antennas. In particular, the present invention relates to the dynamic clustering of sub-carriers in the receiver.

There are now a number of systems which operate at high data rates such as multi-media applications like Wireless Local Area Network (WLAN); Wireless Personal Area Network (WPAN), e.g. Bluetooth; etc. Various arrangements have been proposed in order to facilitate such high data rates in a reliable and practical way. However, there are a number of problems associated with high data rate wireless channels, particularly due to multipath. This is especially problematic indoors where the environment is particularly dispersive due to the large number of objects and surfaces as well as the dynamic nature of structures, particularly people, moving about. Consequently, it can become extremely difficult to extract and retrieve the original information reliably and without extremely complex processing. This results in extremely complex receivers which must be capable of estimating and compensating for the multiple versions of the original signal arriving at the receiver due to the variation in the path length of each version.

In order to counter this, a multi-carrier approach has been proposed in which the original data stream is separated into a series of parallel data streams, each of which is modulated and transmitted with a different frequency, generally within the same band. This allows the relative size of the transmitted symbols to the multipath delay to be much larger and so inter symbol interference is reduced. One particularly advantageous system, which utilises multiple carriers is Orthogonal Frequency Division Multiplexing (OFDM).

OFDM is very effective at overcoming the problems of fading and multipath. This is achieved by dividing a frequency selective fading channel (i.e. a channel where the fading characteristics at one frequency are likely to be different to those at neighbouring frequencies i.e. the profile of the received signal against frequency is not flat) into a number of flat fading sub-bands such that the profile within the sub-bands is approximately flat. These sub-bands relate to the OFDM sub-carrier frequencies.

Figure 1 shows an example of the layout of a transmitter 10 and receiver 20 for an OFDM system. In the multi-antenna receiving unit 21, each of the antennas receives a signal which is fed to an analogue to digital converter 22 and then into a serial to parallel converter 23 to separate the individual sub-channels. The sub channels are then processed through a Fast Fourier Transform (FFT) 24. Finally, the signals are converted from a plurality of parallel signals into a serial signal for each sub-channel and the coded data extracted.

In such an OFDM receiver system, it is possible to apply adaptive beamforming weights at various points in a receiver as shown in Figure 1. However, the effectiveness of these weightings will largely depend on the stability and coherency of the propagation channel. If the channel undergoes flat fading, then it can be regarded as being a narrowband channel and a single set of weights can be applied at radio frequency (RF) or intermediate frequency (IF), to the received signal just after the antenna array 21, i.e. at position (1) in Figure 1. Alternatively, the weights may be applied after the analogue to digital unit 22 at position (2) in Figure 1. Both of these positions should be sufficient for optimum spatial processing.

However, in wideband systems operating at high data rates such as WLAN, WPAN, etc. where bandwidths of 10 MHz or higher may be required and/or systems operating in highly dispersive environments, signals will occupy a spectrum in excess of the coherence bandwidth, i.e. there will be significant variation in the quality/signal strength of the channels across the bandwidth. Consequently, it is unlikely that a single set of weights (i.e. as in narrowband beamforming) would be satisfactory for beamforming.

One way to overcome this problem is to process the received data and apply weightings in the receiver for each sub-carrier, after the FFT 24, i.e. at position (3). However, this is very processor intensive. Figure 6 shows an example of a receiver. In this system, the signal is received by antennas 101,102,103. Pre-processing units 104,105,106, carry out downconversion, A to D conversion, serial to parallel conversion and FFT processing. The outputs are then fed into an array of adaptive signal processing devices 107,108,109 which include a plurality of multipliers 110 which multiply each of the received signals by a weighting value w determined by a weight determining unit 113. Each of the weighted signals from the multipliers is then summed 111 to provide an output signal. The output signals from each of the weighting units is then fed to a combining unit 112 which extracts a data signal in which the delayed signals and interference signals have been removed from the received signal.

However, in the example shown, the receiver has L antennas and the number of sub-channels that each antenna receives is N. Therefore, the total number of weighting units required is L x N. This can lead to a very large number of multipliers 110 being required. For example, in the HIPERLAN system, there are 48 data sub-carriers and 4 pilot sub-carriers (N=52); there is also a DC channel (CH0) which does not carry data. This means that the receiver is complicated and this in turn results in the receiver being expensive and potentially subject to reliability problems. In addition, the weighting is normally implemented in software an so processor demand is extremely high, again resulting in high expense or poor performance. If the processing to determine the weighting to be applied is unduly complex, then it may take a significant amount of time to complete. During this time, the channel parameters may have changed significantly and so the calculated weightings could be inappropriate. Under these circumstances, the weighting produced would always out of date and hence poor performance will result where the characteristics of the channel change rapidly with time.

One way to reduce the processor demand, is to divide the operating bandwidth into a number of sub-bands and then select one sub-carrier from within each sub-band on

which to base all calculations. This method relies upon each sub-band behaving generally as a narrowband, i.e. that the sub-band effectively undergoes flat fading. In other words the chosen sub-carrier is accurately representative of the fade within the sub-band as a whole. However, without prior knowledge of the operational environment, it is difficult to know to what extent the operating band should be divided up. Where the sub-bands are chosen to be large there is a danger that the chosen sub-carrier would not be sufficiently representative of the sub-band and performance would be degraded. In contrast, if the number of sub-bands is chosen to be large, whilst the representative sub-carrier is likely to be accurately representative of the sub-band, the amount of processing required is disadvantageously high.

EP-A2-0,852,407, which relates to current standards for 5 GHz WLANs, suggests reducing the total number of adaptive signal processing units and hence the number of weighting units to improve the receivers by reducing the complexity. The document describes dividing the operating band into four equal sub-bands each having a 'pilot' sub-carrier.

An example of this arrangement is shown in Figure 2 where the operating band is divided into fifty-three channels or sub-carriers (i.e. as in HIPERLAN), these are then divided up into four separate groups each defining a sub-band. Each sub-band includes a sub-carrier which acts as a pilot for the group. The pilot channels do not carry signal data but contain a predetermined sequence for use in equalising the received signal by comparing the received signal to an expected signal. Weighting for the received signals is determined using the pilot sub-carriers and is then applied to each sub-carrier in the respective sub-band. As indicated above this system relies upon flat fading over the sub-bands which in the case of the above referenced document are of the order of 5 Mhz in size.

If the bandwidth of the system is increased such that the sub-bands have considerably greater bandwidth, for example in the region of 10 Mhz, then the likelihood that the sub-

bands will have flat fading is considerably reduced particularly where the environment is such as to give strong multipath interference, e.g. indoors.

Therefore according to the present invention there is provided an adaptive weighting system comprising:

frequency domain transform means for converting a received signal to a plurality of sub-channels;

banding means for allocating a sub-channel to a sub-band based upon a determination of the coherency of some or all of said sub-channels;

weight calculation means for determining a weighting for each sub-band; and

weighting means for applying the respective determined weight for each sub-band to the or each sub-channel of the sub-band.

The present invention further provides a method of processing sub-channels of a received broadband signal comprising:

transforming a received signal into a frequency domain signal,

determining the coherency of each sub-channel of the signal relative to other sub-channels;

allocating each sub-channel to one or more sub-bands based upon said determination of the coherency;

determining weights to be applied to each sub-band based upon a determined coherency of the sub-band; and

applying the determined weights for a sub-band to each of the sub-channels in that sub-band.

The banding means preferably allocates a sub-channel to a sub-band based upon the coherency of that channel being within a predetermined amount of the other sub-channels which have already been allocated to that sub-band. The maximum difference in coherency is preferably within 3dB of the other sub-channels of the sub-band. The maximum difference in coherency is preferably within 0.5 degrees of the other sub-channels of the sub-band.

The system preferably monitors the coherency of the sub-channels within a sub-band to ensure that they continue to remain within a certain range of the other sub-channels of the sub-band. The range may be the same as the predetermined amount or it may be larger.

The present invention applies the same weighting to each member of a sub-band. This means that only one weighting value must be calculated for each sub-band, considerably reducing the processing demand compared to calculating a weighting value for each sub-channel. This in turn allows the weightings to be determined more quickly and so there is less delay between the signal being received and the appropriate weightings being determined. This ensures that the weightings are more up to date and hence accurate.

A specific embodiment of the present invention will now be described in detail by reference to the drawings, in which:-

Figure 1 shows a block diagram showing a typical arrangement of transmitter and receiver for use in an OFDM system;

Figure 2 shows a representation of a system in which the operating band is divided into sub-bands;

Figure 3 shows an overview of a typical OFDM receiver;

Figure 4 shows a schematic representation of a basic receiver architecture for broadband adaptive antenna weight calculation;

Figure 5 shows a flow diagram of the operation of the OFDM receiver of the present invention; and

Figure 6 is a schematic diagram showing the structure of a conventional adaptive antenna system.

Figure 3 shows the functional layout of the baseband section of an OFDM receiver used in the present invention. Many of the functions of the receiver shown as well known

and so only a brief explanation is given here. The received signal is quadrature (I and Q) downconverted, amplified and filtered (not shown) before being (over-)sampled by the A/D unit. The digital over-sampled signal is then filtered and decimated. The over-sampling of the signal at the start aids the digital filtering process, after which it is then rate reduced to the required/expected sample rate. It is assumed in this case that the system provides for a preamble of some sort in every burst within a frame (MAC frame). In the case of HIPERLAN, each frame comprises a preamble portion which is made up of three basic OFDM symbols denoted her as A,B and C. A and B (or even C) symbols can be observed (recovered) in the time domain (pre-FFT) and used to establish the frame and frequency synchronisation (as well as set the FFT window for the data that follows these symbols) through some correlation process. The automatic gain control (AGC) settings (not shown – prior to ADC) can also be established. It is possible to pass the C symbol through as a complete symbol to the FFT. Knowing what this symbol is in advance (and assuming adequate synchronisation), the channel variation can be estimated on a sub-carrier basis post-FFT. The C symbol would be 'switched' out to estimate the channel compensation (rotation of the symbols in the sub-carriers). However, this same channel estimation could be used in the sub-carrier grouping procedure.

Alternatively, pilots can be selected post-FFT and used to estimate the channel over time. The pilots have known symbols in them and are processed to identify what symbol is received (I' and Q') and what symbol was expected (I and Q). If $I' \neq I$ and $Q' \neq Q$ then you can calculate the phase rotation and amplitude change required to make them equal. Given four estimates of these values (4 pilots) you can estimate or interpolate the amplitude and phase rotation required for all the intermediate sub-carriers. This is known as a one-tap equalisation which is a simple if not crude way to determine the correction needed for all the channels. The determined value of the sub-carrier's amplitude and rotation (I and Q) correction value can then be applied. The remainder of the system carries out the unpacking and unscrambling of the data to the relevant bits.

It should be noted that the preamble symbols are there for 'training' or synchronisation purposes i.e. they are known at the receiver so that it can form an estimate of the influences of the channel for an equaliser or even smart antenna weight calculation.

The basic operation of the receiver system will now be described with reference to figure 5. Data is transmitted in blocks of data known as symbols. These symbols typically comprise a guard interval for reducing inter-symbol interference as well as a useful data part. Each symbol is transmitted on a sub-channel using the sub-carriers referred to above. The data to be transmitted is divided up into symbols which are then sent on each of the sub-channels and re-constructed at the receiver. In addition, the series of symbols transmitted generally include one or more preamble symbols, as indicated above for providing control and synchronisation information etc.

Initially, at step S1, the receiver performs a first estimate of the variation of the fading across the entire band using the preamble symbol, in the frequency domain. An estimate of the band is obtained in quadrature (I and Q) information. The 'flatness' of the received power across the sub-carriers and phase differences can be obtained.

At step S2, the receiver divides the sub-carriers across the band into groups of sub-carriers to form sub-bands. The sub-carriers are grouped with other sub-carriers which are within a certain range of each other. The received power and phase differences do not have to be absolutely equal but just sufficiently close to be within a certain range. The range may be varied depending upon the circumstances. By making the range small, the groups of sub-carriers will be small but very coherent. In contrast, if the range is large, the groups can be much larger but they could be less coherent. The range is therefore selected according the available processing power, required reception quality and so on. A typical value for the range could be that if sub-carriers are within 3dB of received power and 0.5 degrees of variation.

Then for each group, the appropriate weightings are determined based on one sub-carrier of the group, and those weightings are applied for all of the sub-carriers in that

group. The weights are determined, as indicated above, such that the level of coherence within each sub-band is suitable for the efficient and effective application of a single set of adaptive array weights for all sub-carriers based on a calculation for a single sub-carrier's performance, i.e. all sub-carriers within the group can be considered to be within the coherence bandwidth of the current channel.

As indicated above, the appropriate weightings are determined based on one sub-carrier of the group. The chosen sub-carrier should in principle be representative of the group so that when the weightings are applied, they are applicable to all members of the group. In practice, it would be very processor intensive to test each sub-carrier to determine which one was most representative. Therefore, the selection of the sub-carrier is selected using other criteria. A number of criteria can be used. If the sub-carrier includes a pilot carrier then this can be used as this has a known data content and will provide a fairly accurate representation of the fading of that channel and hence the group. Clearly not all channels will include a pilot. If you were working with an adaptive antenna algorithm that worked on signal characteristics (rather than data content) then it would probably be satisfactory to pick whichever sub-carrier was central to the group. In essence, unless there is significant fading across the group, then the choice of sub-carrier is not critical and by their very nature, the groups are selected not to have significant fading across them.

By using the same weightings for more than one sub-carrier, the total number of calculations needed to determine the weights for each of the sub-carriers can be reduced. Once the weightings have been determined, the weights can be applied to the sub-band for as long as the sub-band retains sufficient coherency. The coherency of the band will vary over time, particularly due to environmental variations. In order to ensure this, the coherency the sub-carriers is periodically monitored. The frequency of checking the coherency will depend on the variability of the environment. If the environment is generally stable for long periods then checking can be less frequent but in a highly variable environment, regular checking will be required.

Where the data transfer traffic is very bursty, i.e. data is received in short bursts with possibly long periods of no data in-between then it may not be possible to monitor constantly and it may only be possible to form a single estimate of the groups. In contrast where communication is fairly constant, such as in voice communication, it may be possible to make several estimates for determining the groups.

Furthermore, with bursty traffic, if an estimate is made, this may out of date by the time the next estimate is made in a subsequent burst if the period between bursts is longer than the period in which a channel remains coherent. Signal interference will vary over time due to changes in environmental influences particularly if the transmitter or receiver is moving. Consequently where the data is bursty, there may be insufficient time to make more than one estimation. Thus the estimation may have to be carried out on the basis of a few or even a single frame of data. However, in the case of adaptive algorithms, i.e. ones that take a period of time (several samples rather than one) to converge to an answer, if the input conditions change, then clearly they need to re-converge to take account of the new environment. However, this may potentially be from a known converged point which may increase the convergeance rate. In other words, the weights used for a particular transmitter could be used as a starting point for the next set of measurements and determination of sub-banding groups. So rather than starting from scratch each time, the process can begin based upon the conditions determined in the previous determination. Hence they can adapt or are adaptive. These algorithms usually require some sort of training sequence (which could be a preamble) and so work in a similar way to equalisers, even using the same or similar algorithmic techniques.

The coherency of the groups is periodically monitored (step S3) to ensure that they remain within predetermined limits. The coherency may be checked to ensure that the members of the group are still within the range of values used to determine the groups initially. Alternatively the range may be slightly larger to allow some decrease in the coherency (to avoid a very small reduction in coherency precipitating a complete re-assessment of the groupings). If the coherency of any of the sub-carriers in a group is

below the predetermined level, then all the groups are re-assessed as above and the sub-carriers reallocated to a new set of groups. Alternatively, just the weights could be re-assessed if the coherency is still within another limit. As a further alternative, rather than reassess all the groups, if only one group is out of range then it may be possible to divide just that group into two or more new groups which in themselves are sufficiently coherent. Although this increases the number of groups, this may be acceptable as an interim measure to avoid having to re-assess all of the groups.

As indicated above, the determination of the sub-banding is based upon calculations on the preamble channels. However, the calculations can also be on the pilot channels provided in the received signal or on known modulation or signal characteristics such as direction of arrival estimation (Fourier method, ESPRIT, MUSIC) and blind optimal combining (least squares, recursive least squares, sample matrix inversion etc.)

An explanation of the operation of a circuit according to the present invention will now be described with reference to figure 4. The arrangement shown is similar to the prior art systems in that it comprises a plurality of antennas 401 for receiving a transmitted signal. A receiver unit 410 carries out pre-processing of the signal from each antenna to filter the received signal and carry out downconversion. The signal is also prepared for processing in the receiver unit 410 by carrying out A to D conversion. The received signals from each receiver unit 410 are then transformed by a respective FFT 402. The output from each FFT is then passed to an adaptive weighting unit 403. The output from each FFT is also passed to a signal estimating unit 404 associated with each FFT. The signal estimating unit 404 is primarily to carry out channel estimation for the allocation of each channel to a group. This can comprise a correlator for part of the preamble that has been passed through the FFT or the pilot symbols for a longer estimation method (the pilot symbols run throughout the burst whereas the preamble only occurs for the first few symbols of a burst, see figure 2). In figure 2, the bottom axis is frequency and the side axis represents time in symbol durations. The preamble lies at the start of the transmission, and the pilots, which are shown shaded, run through the entire burst. The remainder are the normal sub-carriers for carrying payload data.

The parameter estimation units 407 receive the results of the channel estimation from the signal estimators 404. Based on the determined groups, this unit calculates the weightings for each group according to the selected representative sub-carrier from each group. The parameter estimation circuit 407 controls the spatial weight controllers 405, associated with the adaptive weighting unit 403 in each branch, to output the appropriate weightings for each channel of the adaptive weighting unit. The adaptive weighting units apply the determined weightings to each of the channels of data received from the FFTs. The weighted outputs are then provided to respective adders 406. An adder 406 is provided for each sub-carrier rather than each branch. The adders 406 sum the appropriately weighted channels from each FFT. The output from each adder represents a filtered sub-carrier signal derived from the plurality of delayed signals received by the antennas.

Although, the units described above are indicated as separate. In fact most of the calculations will be carried in a processor such as a DSP and not in discrete hardware units although this is not essential. It is typical for all operations after the A to D conversion to be carried in a software controlled DSP.

The present invention is particularly advantageous when used with more complex algorithms, particularly ones where forming a channel estimate that will require an amount of processing time dependant on the number of sub-carriers. For example, if you are using an 'adaptive' scheme that is going to need hundreds of samples to converge, it is clearly advantageous to limit the number of sub-carriers it needs. In this way, reducing the number of sub-carriers by grouping, will advantageously reduce the processing time to determine the weightings. In contrast, if a 'simple' algorithm is used then the grouping process may actually add extra complexity to the whole procedure.

These systems are intended to cover operation over relatively large overall bandwidths. For example, HIPERLAN may operate in the bands 5.15-5.35GHz AND 5.47 to 5.725GHz, so with both these bands it may arise that the channel is extended. However, one set of sub-carriers may be a long way off the next set, in frequency. Consequently,

when the groups are being determined it may be necessary to apply some bounding conditions. This avoids the system trying to group together spectrally disparate sub-carriers.

CLAIMS:

1. An adaptive weighting system comprising:

frequency domain transform means for converting a received signal to a plurality of sub-channels;

banding means for allocating a sub-channel to a sub-band based upon a determination of the coherency of a plurality of said sub-channels;

weight calculation means for determining a weighting for each sub-band; and

weighting means for applying the respective determined weight for each sub-band to the or each sub-channel of the sub-band.

2. An adaptive weighting system according to claim 1 wherein the banding means determines the coherency of each sub-channel.

3. An adaptive weighting system according to claim1 or 2 further comprising control means for controlling the banding means to check the coherency of the sub-channels of the sub-bands to determine that the maximum difference in the coherency of the group is below a predetermined amount.

4. An adaptive weighting system according to claim 3, wherein the control means is adapted to re-assign the sub-channels to new sub-bands if it is determined that the maximum difference in the coherency of the group is below a predetermined amount.

5. An adaptive weighting system according to any one of claims 2 to 4 wherein the coherency measurement is based upon received power and/or phase difference.

6. An adaptive weighting system according to any one of claims 2 to 5 wherein the predetermined amount is 3dB for the received power and/or 0.5 degrees for the phase difference.

7. An adaptive weighting system according to any one of the preceding claims wherein the banding means allocates a sub-channel to a sub-band such that the

coherency of other sub-channels in the sub-band is within a predetermined amount of the coherency of the allocated sub-channel.

8. An adaptive weighting system according to any one of the preceding claims wherein the weight calculation means determines the weighting according to a determined coherency value for the sub-band.

9. An adaptive weighting system according to any one of the preceding claims wherein the weight calculation means determines the weighting according to the coherency of a selected one of the sub-channels of a sub-band.

10. A method of processing sub-channels of a received broadband signal comprising:

transforming a received signal into a frequency domain signal,

determining the coherency of each sub-channel of the signal relative to other sub-channels;

allocating each sub-channel to one or more sub-bands based upon said determination of the coherency;

determining weights to be applied to each sub-band based upon a determined coherency of the sub-band; and

applying the determined weights for a sub-band to each of the sub-channels in that sub-band.

11. A method of processing sub-channels of a received broadband signal according to claim 10 wherein the determination of the coherency of a sub-band is based upon the coherency of a selected sub-channel of that sub-band.

12. A method of processing sub-channels of a received broadband signal according to claim 12, wherein determining the coherency of a sub-channel comprises determining the received power and/or phase difference of the sub-channel.

13. A method of processing sub-channels of a received broadband signal according to claim 10,11 or 12, wherein said determination of said coherency comprises determining that the coherency of the sub-channel is within a predetermined amount of the coherency of the other sub-channels in the group.

14. A method of processing sub-channels of a received broadband signal according to claim 13, wherein the predetermined amount is 3dB for the received power and/or 0.5 degrees for the phase difference.

15. A processor for processing sub-channels of a received broadband signal, the processor being adapted to:

transform received signals into frequency domain signals,

determine the coherency of each sub-channel relative to other sub-channels;

allocate each sub-channel to one or more sub-bands based upon said determination of the coherency;

determine weights to be applied to each sub-band based upon a sub-channel within the sub-band; and

apply the determined weights for each sub-band to each of the sub-channels in the sub-band.

16. An adaptive weighting system substantially as described herein with reference to the accompanying drawings.

17. A method of processing a received broadband signal substantially as described herein with reference to the accompanying drawings.

18. A processor substantially as described herein with reference to the accompanying drawings.

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Application No:	GB 0108026.6	**Examiner:**	Owen Wheeler
Claims searched:	1-18	**Date of search:**	6 December 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4P (PAN, PAR, PAX, PRE)

Int Cl (Ed.7): H04L: 27/26

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2356769 A	[SECRETARY OF STATE FOR DEFENCE]	
X	EP 1037303 A1	[MOTOROLA] See Figure 1 and paragraphs 22,40,45-47.	1-15
A	EP 0851642 A2	[SHARP]	
A	WO 97/40608 A1	[AMATI]	
A	US 6249250 B1	[NAMEKATA]	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		